XT. UTKU/SCHMELE PARABOLOID RMS BEST-FIT PROGRAM

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N67-28732

Program: 5577,000 symbolic in Jet Propulsion Laboratory Library

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Programmer: L. Schmele

A. Program Description

This program computes the coefficients for the equation of a paraboloid of revolution that best fits, in the least-squares sense, a set of coordinates representing points on the surface of a deformed paraboloidal antenna. The distortions, calculated with respect to the points on the best-fitted perfect paraboloid described above, are the normal and the pathlength errors. From the distortions, a weighted RMS of one-half the path length error is computed.

A rigid body fit, i.e., a fit without a change in focal length of the best-fitting paraboloid, is made initially; this is followed by a best fit that includes the focal length change. From the computed vertex position and rotation of the symmetrical axis (z-axis) of the best-fit paraboloid, the RF boresight may be calculated.

Capability is provided to assign values to any of the coefficients (i.e., the vertex x, y, and z translation and the rotation of the symmetrical axis about x-, y- and z-axes) of the best-fitting paraboloid before the fit.

Provision is made to combine and multiply the input distortion data by a constant as required. Separate distortions from symmetric and asymmetric loads may also be inputted and combined before the best fit. Field data in the form of distortion readings at right angles to the line of sight and its elevation angle may be inputted.

Contour plots may be generated on the Stromberg-Carlson 4020 printer-plotter. The contour levels are constant deviations of ½ pathlength from the best-fit paraboloid. Other information on these programs may be found in Refs. 14 and 15.[3]

B. Applications

The vector distortions in x-, y-, and z-directions from the structural computing program, i.e., the STAIR Program (X), may be evaluated with respect to the best-fit paraboloid resulting in the RMS figure for RF evaluation.

[3] See also L. Schmele, "RMS/Fortran IV Program for the Calculation of Weighted Root-Mean-Square of Path-Length Change for Paraboloidal Antennas," Jet Propulsion Laboratory Program Writeup 5577000, September 1965. (See also JPL Space Programs Summary 37-40, Vol. IV.)

Also, the individual distortion at each point or joint is outputted for evaluation. From the vertex motion and the rotation of the axis of symmetry, the RF boresight direction may be computed if the position of the RF feed system is known.

To determine the vector distortions computed by a structural computing program for gravity loads, distortions from gravity *off/on* for the symmetric gravity load and the gravity *off/on* for the anti-symmetric gravity load may be inputted separately. The program will multiply the distortions by an inputted constant and combine them. For this operation, the program is coded to use either the first quadrant or first and fourth quadrant data.

In order to simulate the field data on distortions due to gravity loads, the vertex and axis motion of the best-fitting paraboloid may be assigned values determined by the deflections of the datum targets of the theodolite. The contour levels chart will be useful in comparing the distortions.

C. Input

Card	Parameters	Format
1	*TITLE*	12A6
2	*NOPT NP F C1 C2 YOFF ZOFF XROT*	2I10, 6F10.0
3[a]	*NXOFF NYOFF NZOFF NXROT NYROT*	5I10
4[a]	*XOFF YOFF ZOFF XROT YROT*	5F10.0
5A[b]	*X Y Z U V W A PN*	7F10.3, 4X, A6
5B[b]	*X Y Z θ R DZ A PN*	7F10.3, 4X, A6
.	. . . . .	.
.	. . . . .	.
.	. . . . .	.
NP + 3 or *NP* + 5[a]	*IPLOT C1 C2 C3 C4 C5 C6 C7 C8 C9*	I10, 7F10.4 8F10.4
.		.
.		.
.		.

[a] These cards required only for NOPT = 6 or 7, or −1.

[b] 5A for data from analytic computation; 5B for field data, *NOPT* = 5 or 6.

TITLE = any alphanumeric statement, Columns 1 through 72

NOPT = input option control, described in the tabulation on p. 81.

NP = number of data points, 2000 maximum. For polar matrix plotting, the maximum number of points must be < 28 in the radial direction and < 200 in the circumferential direction

F = nominal focal length

C1 = weighting factor for first set of symmetric data; value ignored except for *NOPT* = ±3 and ±4

C2 = weighting factor for second set of anti-symmetric data; value ignored except for *NOPT* = ±3 and ±4

YOFF = assigned offset of vertex Y-coordinate; value ignored except for *NOPT* = ±4

ZOFF = assigned offset of vertex Z-coordinate; value ignored except for *NOPT* = ±4

XROT = assigned rotation about *x*-axis; value ignored except for *NOPT* = ±4

NXOFF, NYOFF, NZOFF, NXROT, NYROT = 1 for assigned value, or 0 for value to be computed, for *X*-, *Y*-, and Z-coordinates of vertex, and rotation about *x*- and *y*-axes, respectively

XOFF, YOFF, ZOFF, XROT, YROT = assigned values for these parameters to be used or not used as directed by the preceding card

X, Y, Z = coordinates of data points. Z nominally directed along axis of paraboloid. Program recomputes Z to value for nominal paraboloid at given *X*-*Y* coordinates, and writes over any input Z-value, if any

U, V, W = *X*, *Y*, and Z distortion vector components for calculated input data.

θ = angle from X-Y plane, as measured by instrument leveled to datum targets

R = deflection of data point from nominal position, measured perpendicular to instrument line-of-sight

DZ = Z-deflection component. Program computes this value from θ and R and writes over any input value

A = weighting function, normally the area associated with the data point

PN = six-letter alphanumeric point identification

$IPLOT = -1$ = no contour plots

0 = plots with program-computed contour interval levels

N = plots with N-input contour levels $(0 < |N| \leq 26)$

$C1, C2, \cdots, CN$ = N-contour levels desired for $IPLOT = N$

1. Input Options

NOPT	Data	Number of data sets	Quadrants for which data is input	Load symmetry for which data is input (restricted to anti-symmetric loads about the x-axis	Assigned parameters
0	Analytic	1	All four	—	None
+1		1	First	Symmetric	None
−1		1	First	Symmetric or anti-symmetric	Per Cards 3 and 4
+2		1	First (generated fourth)	First and fourth quadrants, anti-symmetric	None
−2		1	First and fourth	Symmetric or anti-symmetric	None
+3		2	First (generated fourth)	First set symmetric; second set anti-symmetric	None
−3		2	First and fourth	First set symmetric; second set anti-symmetric	None
+4		2	First (generated fourth)	First set symmetric; second set anti-symmetric	On Card 2
−4		2	First and fourth	First set symmetric; second set anti-symmetric	On Card 2
+5	Field	1	All four	—	None
+6	Field	1	All four	—	Per Cards 3 and 4
+7	Analytic	1	All four	—	Per Cards 3 and 4

Note:
NOPT + 10 is the same as above except coordinates are input in feet and are internally converted to inches.
Input data to be in consistent linear units, and degrees.

D. Output

This program prints out pertinent input data, point-by-point deflections relative to the computed best-fit paraboloid, and then the parameters of the best-fit paraboloid. Translations and rotations are given with respect to the coordinate system of the input data. Contour plots are output optionally.

E. Sample Case

Sample input

```
TEST OPTION = -3 -1.0 SYMMETRIC PLUS +1.0 ANTI-SYM   HALF DISH DATA
   -3          32        150.0        -1.0          1.0
0035.12    0176.54                 0.00021     0.00678    -0.03844    1499.7    R2111
0026.03    0130.87                -0.00011     0.00409    -0.03302    2380.5    R2112
0016.92    0085.08                -0.00041     0.00202    -0.02716    1667.5    R2114
0005.85    0029.42                -0.00003     0.00078    -0.02447    1304.2    R2116
0100.00    0149.66                 0.00189     0.00974    -0.04156    1499.7    R2118
0074.13    0110.95                 0.00021     0.00552    -0.03283    2380.5    R2119
0048.20    0072.13                -0.00041     0.00315    -0.02655    1667.5    R2121
0016.67    0024.94                -0.00008     0.00085    -0.02369    1304.2    R2126
0149.66    0100.00                -0.00394     0.00331    -0.01554    1499.7    R2201
0110.95    0074.13                -0.00298     0.00253    -0.01637    2380.5    R2202
0072.13    0048.20                -0.00207     0.00211    -0.01794    1667.5    R2204
0024.94    0016.67                -0.00079     0.00024    -0.02180    1304.2    R2209
0176.54    0035.12                -0.01032     0.00022     0.00408    1499.7    R2211
0130.87    0024.83                -0.00817     0.00019    -0.00038    2380.5    R2212
0085.08    0016.92                -0.00553     0.00114    -0.00824    1667.5    R2214
0029.42    0005.85                -0.00164    -0.00003    -0.02061    1304.2    R2216
0176.54   -0035.12                -0.01032    -0.00022     0.00409    1499.7    R2221
0130.87   -0024.83                -0.00817    -0.00019    -0.00038    2380.5    R2222
0085.08   -0016.92                -0.00552    -0.00114    -0.00824    1667.5    R2224
0029.42   -0005.85                -0.00164    -0.00004    -0.02061    1304.5    R2226
0149.66   -0100.00                -0.00395    -0.00331    -0.01554    1499.7    R2228
0110.95   -0074.13                -0.00298    -0.00253    -0.01637    2380.5    R2229
0024.94   -0016.67                -0.00079    -0.00024    -0.02180    1304.2    R2236
0026.03   -0130.87                -0.00011    -0.00409    -0.03302    2380.5    R2312
0016.92   -0085.88                -0.00041    -0.00202    -0.02716    1667.5    R2314
0072.13   -0048.20                -0.00207    -0.00210    -0.01794    1667.5    R2231
0035.12   -0176.54                 0.00021    -0.00678    -0.03844    1499.7    R2311
0005.85   -0029.42                -0.00003    -0.00078    -0.02447    1304.2    R2316
0100.00   -0149.66                 0.00189    -0.00974    -0.04156    1499.7    R2318
0074.13   -0110.95                 0.00021    -0.00552    -0.03283    2380.5    R2319
0048.20   -0072.13                -0.00041    -0.00315    -0.02655    1667.5    R2321
0016.67   -0024.94                -0.00008    -0.00085    -0.02369    1304.2    R2326
0035.12    0176.54                -0.00006    -0.07099     0.10740    1499.7    R2111
0026.03    0130.87                 0.00014    -0.04919     0.06637    2380.5    R2112
0016.92    0085.08                -0.00075    -0.03913     0.04066    1667.5    R2114
0005.85    0029.42                 0.00003    -0.03379     0.01264    1304.2    R2116
0100.00    0149.66                -0.00115    -0.07355     0.09368    1499.7    R2118
0074.13    0110.95                -0.00092    -0.05247     0.05968    2380.5    R2119
0048.20    0072.13                -0.00187    -0.04158     0.03695    1667.5    R2121
0016.67    0024.94                -0.00064    -0.03553     0.01317    1304.2    R2126
0149.66    0100.00                -0.00004    -0.07231     0.06304    1499.7    R2201
0110.95    0074.13                -0.00143    -0.05351     0.04467    2380.5    R2202
0072.13    0048.20                -0.00173    -0.04118     0.02653    1667.5    R2204
0024.94    0016.67                -0.00041    -0.03535     0.00878    1304.2    R2209
0176.54    0035.12                 0.00617    -0.06955     0.01153    1499.7    R2211


0130.87    0024.83                 0.00016    -0.05315     0.01568    2380.5    R2212
0085.08    0016.92                -0.00026    -0.04026     0.00890    1667.5    R2214
0029.42    0005.85                 0.00003    -0.03519     0.00302    1304.2    R2216
0176.54   -0035.12                -0.00618    -0.06955    -0.01153    1499.7    R2221
0130.87   -0024.83                -0.00016    -0.05315    -0.01568    2380.5    R2222
0085.08   -0016.92                 0.00026    -0.04026    -0.00890    1667.5    R2224
0029.42   -0005.85                -0.00003    -0.03520    -0.00302    1304.5    R2226
0149.66   -0100.00                 0.00004    -0.07231    -0.06304    1499.7    R2228
0110.95   -0074.13                 0.00143    -0.05351    -0.04467    2380.5    R2229
0072.13   -0048.20                 0.00173    -0.04118    -0.02653    1667.5    R2231
0024.94   -0016.67                 0.00041    -0.03536    -0.00878    1304.2    R2236
0035.12   -0176.54                 0.00006    -0.07099    -0.10740    1499.7    R2311
0026.03   -0130.87                -0.00014    -0.04919    -0.06637    2380.5    R2312
0016.92   -0085.88                 0.00075    -0.03913    -0.04066    1667.5    R2314
0005.85   -0029.42                -0.00003    -0.03379    -0.01264    1304.2    R2316
0100.00   -0149.66                 0.00115    -0.07355    -0.09368    1499.7    R2318
0074.13   -0110.95                 0.00092    -0.05247    -0.05968    2380.5    R2319
0048.20   -0072.13                 0.00187    -0.04158    -0.03695    1667.5    R2321
0016.67   -0024.94                 0.00064    -0.03553    -0.01317    1304.2    R2326
   0
-EOF
```

Sample output

BEST FIT PARABOLOID WITH MINIMUM PATH LENGTH IN LEAST SQUARES SENSE

TEST OPTION = -3 -1.0 SYMMETRIC PLUS +1.0 ANTI-SYM HALF DISH DATA

INPUT DATA FOR FIRST LOAD - SYMMETRIC

X COORDINATE	Y COORDINATE	Z COORDINATE	X DEFLECTION	Y DEFLECTION	Z DEFLECTION	AREA	POINT NO.
35.120	176.540	54.000	0.000	0.007	-0.038	1499.700	R2111
26.030	130.870	29.674	-0.000	0.004	-0.033	2380.500	R2112
16.920	85.080	12.541	-0.000	0.002	-0.027	1667.500	R2114
5.850	29.420	1.500	-0.000	0.001	-0.024	1304.200	R2116
100.000	149.660	53.997	0.002	0.010	-0.042	1499.700	R2118
74.130	110.950	29.675	0.000	0.006	-0.033	2380.500	R2119
48.200	72.130	12.543	-0.000	0.003	-0.027	1667.500	R2121
16.670	24.940	1.500	-0.000	0.001	-0.024	1304.200	R2126
149.660	100.000	53.997	-0.004	0.003	-0.016	1499.700	R2201
110.950	74.130	29.675	-0.003	0.003	-0.016	2380.500	R2202
72.130	48.200	12.543	-0.002	0.002	-0.018	1667.500	R2204
24.940	16.670	1.500	-0.001	0.000	-0.022	1304.200	R2209
176.540	35.120	54.000	-0.010	0.000	0.004	1499.700	R2211
130.870	24.830	29.572	-0.008	0.000	-0.000	2380.500	R2212
85.080	16.920	12.541	-0.006	0.001	-0.008	1667.500	R2214
29.420	5.850	1.500	-0.002	-0.000	-0.021	1304.200	R2216
176.540	-35.120	54.000	-0.010	-0.000	0.004	1499.700	R2221
130.870	-24.830	29.572	-0.008	-0.000	-0.000	2380.500	R2222
85.080	-16.920	12.541	-0.006	-0.001	-0.008	1667.500	R2224
29.420	-5.850	1.500	-0.002	0.000	-0.021	1304.500	R2226
149.660	-100.000	53.997	-0.004	-0.003	-0.016	1499.700	R2228
110.950	-74.130	29.675	-0.003	-0.003	-0.016	2380.500	R2229
24.940	-16.670	1.500	-0.001	-0.000	-0.022	1304.200	R2236
26.030	-130.870	29.674	-0.000	-0.004	-0.033	2380.500	R2312
16.920	-85.880	12.769	-0.000	-0.002	-0.027	1667.500	R2314
72.130	-48.200	12.543	-0.002	-0.002	-0.018	1667.500	R2231
35.120	-176.540	54.000	0.000	-0.007	-0.038	1499.700	R2311
5.850	-29.420	1.500	-0.000	-0.001	-0.024	1304.200	R2316
100.000	-149.660	53.997	0.002	-0.010	-0.042	1499.700	R2318
74.130	-110.950	29.675	0.000	-0.006	-0.033	2380.500	R2319
48.200	-72.130	12.543	-0.000	-0.003	-0.027	1667.500	R2321
16.670	-24.940	1.500	-0.000	-0.001	-0.024	1304.200	R2326

BEST FIT PARABOLOID WITH MINIMUM PATH LENGTH IN LEAST SQUARES SENSE

TEST OPTION = -3 -1.0 SYMMETRIC PLUS +1.0 ANTI-SYM HALF DISH DATA

INPUT DATA FOR SECOND LOAD - ANTI-SYMMETRIC

X COORDINATE	Y COORDINATE	Z COORDINATE	X DEFLECTION	Y DEFLECTION	Z DEFLECTION	AREA	POINT NO.
35.120	176.540	54.000	-0.000	-0.071	0.107	1499.700	R2111
26.030	130.870	29.674	0.000	-0.049	0.066	2380.500	R2112
16.920	85.080	12.541	-0.001	-0.039	0.041	1667.500	R2114
5.850	29.420	1.500	0.000	-0.034	0.013	1304.200	R2116
100.000	149.660	53.997	-0.001	-0.074	0.094	1499.700	R2118
74.130	110.950	29.675	-0.001	-0.052	0.060	2380.500	R2119
48.200	72.130	12.543	-0.002	-0.042	0.037	1667.500	R2121
16.670	24.940	1.500	-0.001	-0.036	0.013	1304.200	R2126
149.660	100.000	53.997	-0.000	-0.072	0.063	1499.700	R2201
110.950	74.130	29.675	-0.001	-0.054	0.045	2380.500	R2202
72.130	48.200	12.543	-0.002	-0.041	0.027	1667.500	R2204
24.940	16.670	1.500	-0.000	-0.035	0.009	1304.200	R2209
176.540	35.120	54.000	0.006	-0.070	0.012	1499.700	R2211
130.870	24.830	29.572	0.000	-0.053	0.016	2380.500	R2212
85.080	16.920	12.541	-0.000	-0.040	0.009	1667.500	R2214
29.420	5.850	1.500	0.000	-0.035	0.003	1304.200	R2216
176.540	-35.120	54.000	-0.006	-0.070	-0.012	1499.700	R2221
130.870	-24.830	29.572	-0.000	-0.053	-0.016	2380.500	R2222
85.080	-16.920	12.541	0.000	-0.040	-0.009	1667.500	R2224
29.420	-5.850	1.500	-0.000	-0.035	-0.003	1304.500	R2226
149.660	-100.000	53.997	0.000	-0.072	-0.063	1499.700	R2228
110.950	-74.130	29.675	0.001	-0.054	-0.045	2380.500	R2229
72.130	-48.200	12.543	0.002	-0.041	-0.027	1667.500	R2231
24.940	-16.670	1.500	0.000	-0.035	-0.009	1304.200	R2236
35.120	-176.540	54.000	0.000	-0.071	-0.107	1499.700	R2311
26.030	-130.870	29.674	-0.000	-0.049	-0.066	2380.500	R2312
16.920	-85.880	12.769	0.001	-0.039	-0.041	1667.500	R2314
5.850	-29.420	1.500	-0.000	-0.034	-0.013	1304.200	R2316
100.000	-149.660	53.997	0.001	-0.074	-0.094	1499.700	R2318
74.130	-110.950	29.675	0.001	-0.052	-0.060	2380.500	R2319
48.200	-72.130	12.543	0.002	-0.042	-0.037	1667.500	R2321
16.670	-24.940	1.500	0.001	-0.036	-0.013	1304.200	R2326

Sample output (contd)

BEST FIT PARABOLOID WITH MINIMUM PATH LENGTH IN LEAST SQUARES SENSE

TEST OPTION = -3 -1.0 SYMMETRIC PLUS +1.0 ANTI-SYM HALF DISH DATA

SUM OF INPUT DEFLECTIONS

X COORDINATE	Y COORDINATE	Z COORDINATE	X DEFLECTION	Y DEFLECTION	Z DEFLECTION	AREA	POINT NO.
35.120	176.540	54.000	-0.000	-0.078	0.146	1499.700	R2111
26.030	130.870	29.674	0.000	-0.053	0.099	2380.500	R2112
16.920	85.080	12.541	-0.000	-0.041	0.068	1667.500	R2114
5.850	29.420	1.500	0.000	-0.035	0.037	1304.200	R2116
100.000	149.660	53.997	-0.003	-0.083	0.135	1499.700	R2118
74.130	110.950	29.675	-0.001	-0.058	0.093	2380.500	R2119
48.200	72.130	12.543	-0.001	-0.045	0.064	1667.500	R2121
16.670	24.940	1.500	-0.001	-0.036	0.037	1304.200	R2126
149.660	100.000	53.997	0.004	-0.076	0.079	1499.700	R2201
110.950	74.130	29.675	0.002	-0.056	0.061	2380.500	R2202
72.130	48.200	12.543	0.000	-0.043	0.044	1667.500	R2204
24.940	16.670	1.500	0.000	-0.036	0.031	1304.200	R2209
176.540	35.120	54.000	0.016	-0.070	0.007	1499.700	R2211
130.870	24.830	29.572	0.008	-0.053	0.016	2380.500	R2212
85.080	16.920	12.541	0.005	-0.041	0.017	1667.500	R2214
29.420	5.850	1.500	0.002	-0.035	0.024	1304.200	R2216
176.540	-35.120	54.000	0.004	-0.069	-0.016	1499.700	R2221
130.870	-24.830	29.572	0.008	-0.053	-0.015	2380.500	R2222
85.080	-16.920	12.541	0.006	-0.039	-0.001	1667.500	R2224
29.420	-5.850	1.500	0.002	-0.035	0.018	1304.500	R2226
149.660	-100.000	53.997	0.004	-0.069	-0.048	1499.700	R2228
110.950	-74.130	29.675	0.004	-0.051	-0.028	2380.500	R2229
24.940	-16.670	1.500	0.001	-0.035	0.013	1304.200	R2236
26.030	-130.870	29.674	-0.000	-0.045	-0.033	2380.500	R2312
16.920	-85.880	12.769	0.001	-0.037	-0.013	1667.500	R2314
72.130	-48.200	12.543	0.004	-0.039	-0.009	1667.500	R2231
35.120	-176.540	54.000	-0.000	-0.064	-0.069	1499.700	R2311
5.850	-29.420	1.500	0.000	-0.033	0.012	1304.200	R2316
100.000	-149.660	53.997	-0.001	-0.064	-0.052	1499.700	R2318
74.130	-110.950	29.675	0.001	-0.047	-0.027	2380.500	R2319
48.200	-72.130	12.543	0.002	-0.038	-0.010	1667.500	R2321
16.670	-24.940	1.500	0.001	-0.035	0.011	1304.200	R2326

BEST FIT PARABOLOID WITH MINIMUM PATH LENGTH IN LEAST SQUARES SENSE

TEST OPTION = -3 -1.0 SYMMETRIC PLUS +1.0 ANTI-SYM HALF DISH DATA

DISTORTIONS NORMAL TO SURFACE AND CHANGE IN PATH LENGTH (LAMBDA)
AFTER MINIMIZATION OF RMS WITH RESPECT TO RIGID BODY MOTION

NORMAL	LAMBDA	POINT NO.
0.018	0.031	R2111
0.007	0.012	R2112
0.005	0.009	R2114
0.002	0.005	R2116
0.026	0.044	R2118
0.012	0.022	R2119
0.008	0.015	R2121
0.004	0.009	R2126
-0.004	-0.006	R2201
-0.000	-0.000	R2202
-0.000	-0.000	R2204
0.002	0.003	R2209
-0.039	-0.066	R2211
-0.020	-0.037	R2212
-0.013	-0.026	R2214
-0.001	-0.001	R2216
-0.015	-0.026	R2221
-0.024	-0.045	R2222
-0.015	-0.028	R2224
-0.001	-0.003	R2226
-0.008	-0.014	R2228
-0.010	-0.018	R2229
-0.001	-0.002	R2236
0.018	0.032	R2312
0.008	0.015	R2314
-0.007	-0.013	R2231
0.018	0.031	R2311
0.004	0.008	R2316
0.019	0.032	R2318
0.013	0.023	R2319
0.004	0.007	R2321
0.000	0.001	R2326

Sample output (contd)

```
BEST FIT PARABOLOID WITH MINIMUM PATH LENGTH IN LEAST SQUARES SENSE

TEST OPTION = -3 -1.0 SYMMETRIC PLUS +1.0 ANTI-SYM   HALF DISH DATA

DISTORTIONS NORMAL TO SURFACE AND CHANGE IN PATH LENGTH (LAMBDA)
AFTER MINIMIZATION OF RMS WITH RESPECT TO FOCAL LENGTH CHANGE

     NORMAL        LAMBDA        POINT NO.
      0.017         0.030          R2111
      0.007         0.012          R2112
      0.005         0.009          R2114
      0.003         0.006          R2116
      0.025         0.043          R2118
      0.012         0.022          R2119
      0.008         0.015          R2121
      0.005         0.010          R2126
     -0.004        -0.007          R2201
     -0.000        -0.001          R2202
      0.000         0.000          R2204
      0.002         0.004          R2209
     -0.039        -0.067          R2211
     -0.021        -0.038          R2212
     -0.013        -0.025          R2214
     -0.000        -0.000          R2216
     -0.016        -0.027          R2221
     -0.025        -0.045          R2222
     -0.015        -0.028          R2224
     -0.001        -0.002          R2226
     -0.008        -0.015          R2228
     -0.010        -0.018          R2229
     -0.001        -0.001          R2236
      0.018         0.032          R2312
      0.008         0.016          R2314
     -0.007        -0.013          R2231
      0.018         0.030          R2311
      0.004         0.009          R2316
      0.018         0.031          R2318
      0.012         0.023          R2319
      0.004         0.007          R2321
      0.001         0.002          R2326

BEST FIT PARABOLOID WITH MINIMUM PATH LENGTH IN LEAST SQUARES SENSE

TEST OPTION = -3 -1.0 SYMMETRIC PLUS +1.0 ANTI-SYM   HALF DISH DATA

ORIGINAL FOCAL LENGTH =   150.000   NO. POINTS IN ANALYSIS =   32

          INPUT DISTORTIONS OBTAINED ANALYTICALLY - OPTION -3

          RIGID BODY TRANSLATIONS IN X DIRECTION CONSTRAINED

            RIGID BODY ROTATIONS ABOUT Y AXIS CONSTRAINED

          RMS =-1.0000 SYMMETRIC AND 1.0000 ANTI-SYMMETRIC

        MINIMIZATION OF RMS WITH RESPECT TO RIGID BODY MOTION

            RMS OF 1/2 LAMBDA WEIGHTED BY AREAS =    0.012

            DEVIATION OF THE MEAN - 1/2 LAMBDAS =    0.00003
            SUM-UNIT AREA*1/2 LAMBDA =               3.594
            SUM-UNIT AREAS           =           54815.498

            X COORDINATE OF VERTEX =                -0.000

            Y COORDINATE OF VERTEX =                 0.312

            Z COORDINATE OF VERTEX =                 0.021

            ROTATION ABOUT X AXIS =                  0.001599

            ROTATION ABOUT Y AXIS =                 -0.000000

        MINIMIZATION OF RMS WITH RESPECT TO FOCAL LENGTH CHANGE

            RMS OF 1/2 LAMBDA WEIGHTED BY AREAS =    0.012

            NEW FOCAL LENGTH =                     149.997

            DEVIATION OF THE MEAN - 1/2 LAMBDAS =    0.00000
            SUM-UNIT AREA*1/2 LAMBDA =               0.000
            SUM-UNIT AREAS           =           54815.498

            X COORDINATE OF VERTEX =                 0.000

            Y COORDINATE OF VERTEX =                 0.312

            Z COORDINATE OF VERTEX =                 0.021

            ROTATION ABOUT X AXIS =                  0.001599

            ROTATION ABOUT Y AXIS =                  0.000000

            ALL LENGTH UNITS ARE CONSISTENT WITH INPUT

            ROTATION UNITS ARE RADIANS

*** PLOTS COMPLETED ***
```

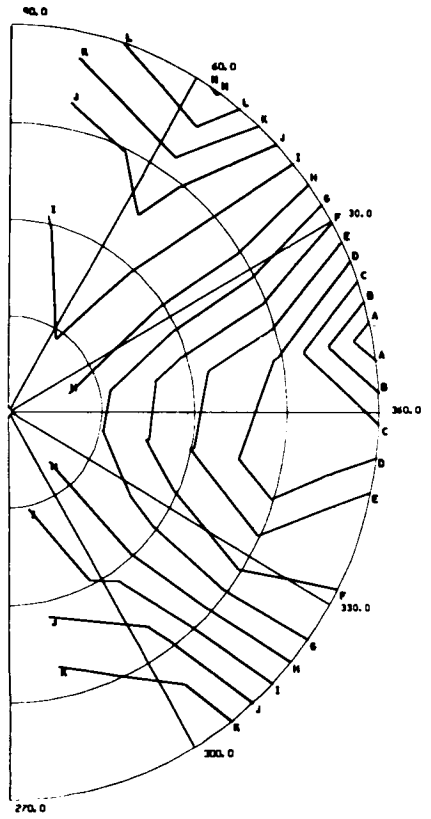
Output, plotted

TEST OPTION = -3 -1.0 SYMMETRIC PLUS +1.0 ANTI-SYM HALF DISH DATA

RIGID BODY FIT RMS = 0.012

CONTOUR DEFINITIONS
1/2 RP PATHLENGTH
ERROR-INCHES LABEL

ERROR-INCHES	LABEL
-0.035	A
-0.030	B
-0.025	C
-0.020	D
-0.015	E
-0.010	F
-0.005	G
-0.000	H
0.005	I
0.010	J
0.015	K
0.020	L
0.025	M



TEST OPTION = -3 -1.0 SYMMETRIC PLUS +1.0 ANTI-SYM HALF DISH DATA

FOCAL LENGTH FIT RMS = 0.012

CONTOUR DEFINITIONS
1/2 RP PATHLENGTH
ERROR-INCHES LABEL

ERROR-INCHES	LABEL
-0.035	A
-0.030	B
-0.025	C
-0.020	D
-0.015	E
-0.010	F
-0.005	G
0.000	H
0.005	I
0.010	J
0.015	K
0.020	L
0.025	M